THURSDAY, MAY 17, 1906.

THE MECHANISM OF THE UNIVERSE.

History of the Planetary Systems from Thales to Kepler. By Dr. J. L. E. Dreyer. Pp. xii+432. (Cambridge: University Press, 1906.) Price 10*s*. 6*d*. net.

BY the publication of this masterly account of the development of cosmogonic ideas and the history of planetary systems from the early dawn of Greek philosophy to the final establishment of the Copernican system, Dr. Dreyer has rendered a great service to those who take an interest in the fascinating history of astronomical science. Throughout the work we have reason to admire his lucid exposition, based on profound historical studies, of the manifold views formed by the thinking minds of antiquity and of the middle ages on the mechanism of the universe, his definite conclusions on many controversial points, and, above all, his endeavour to trace out, as much as possible, the influences of the philosophic and religious tendencies of the time on the cosmological conceptions under view.

The opening chapters describe the development of astronomical ideas among the Greeks. After a brief review of the cosmogony of the early atomistic school we are introduced to the more distinct teachings of the Pythagoreans. To their conception of the revolution of the earth round the central fire, notwithstanding its crudeness, distinct merit must be attributed, if judged by the favourable influence which the teaching of Philolaus exerted on the propagation of the Copernican system among those "who could only admire philosophers of classical antiquity." Complicated and erroneous as the Pythagorean idea was, it nevertheless paved the way for the true conception of the earth's rotation, but not, as was often believed, for the heliocentric system. The chapter on the primitive geocentric cosmology of Plato may, at first sight, appear somewhat too prominent. Considering, however, the various controversies to which Plato's astronomical system has given rise, a clear statement of his natural philosophy on the basis of an exhaustive analysis of the Dialogues is of importance, even apart from the author's apology that "there is a charm in the poetical conception of the 'soul of the world' which makes the study of the *Timaeus* peculiarly attractive."

With Eudoxus and Kalippus astronomy has started on its career as a science. Eudoxus is the first to go beyond mere speculative reasoning; he distinctly bases his system of the homocentric spheres on the demand of satisfying the observed motions. The possibilities of this mathematically elegant system, recently pointed out by Ideler and Schiaparelli, were, however, not much appreciated by the ancients, although Aristotle had accepted it in the improved version of Kalippus.

Dr. Dreyer's criticism of Aristotelian metaphysics is severe.

"His careful and critical examination of the opinions of previous philosophers makes us regret all the more that his search for the causes of phenomena was often a mere search among words. This tendency, which to us is his great defect, appealed strongly to the medieval mind and helped to retard the development of science in the days of Copernicus and Galileo."

The attempts of finding the physically true system of the world terminated with Herakleides, who taught the rotation of the earth, and Aristarchus, who proposed, as a way of "saving the phenomena," that the earth performed an annual motion round the sun. But the rapid rise of practical astronomy in the Alexandrian school had so enormously increased the knowledge of the complexities of the planetary motions, which none of the proposed systems could explain, that henceforth the idea of grasping the physical truth was altogether abandoned, and attention became concentrated upon a purely geometrical interpretation of the celestial phenomena.

The subsequent exposition of the theory of the epicycles and their utilisation in the Ptolemaic system naturally forms an important part of Dr. Dreyer's work. We cannot enter here upon his valuable account of the work of Apollonius, Hipparchus, Eratosthenes, and Ptolemy; nor can we dwell upon his fascinating picture of the advances in astronomical knowledge during the Alexandrian era, including, as they do, the discovery of the precession by Hipparchus, the mensuration of the earth by Eratosthenes, and general conclusions as to the dimensions of the universe. The chapter closes with a graphic account of the rapid decline of Hellenic culture after the destruction of the Alexandrian library, when "the curtain went down for ever on the great stage where Greek science had played its part so well and so long."

The return to archaic cosmology in Europe under patristic influence and the supreme sway of Aristotelian metaphysics in scholasticism, mark an epoch of scientific decadence in gloomy contrast to the flourishing period of Hellenic culture. But the same epoch is distinguished by the intense cultivation of Greek astronomy among the Arabs, whose labours, devoted to the further development of the Ptolemaic system, are expounded in chapter xi. Although no direct advance in cosmic ideas accrued from their work, they influenced the subsequent advancement of European astronomy in a most important manner by their invention of the trigonometric calculus.

The description of the revival of astronomy in Europe brings us face to face with some interesting philosophers of the pre-Copernican period. The vague and often mystic speculation of Cusa is contrasted with the practical merits of Peurbach and Regiomontanus, who successfully endeavoured to utilise the Ptolemaic system for the purposes of astronomical calculation, while we also find an interesting account of the hopelessly complicated attempts made by Fracastoro and Amici to revive the theory of solid spheres, and thereby to prove the physical truth of the Alexandrian system.

© 1906 Nature Publishing Group

The three closing chapters dealing with Copernicus, Tycho, and Kepler are naturally those which command our special interest. They contain far more than mere statements of the works of these great heroes of astronomical science. They define clearly the specific *rôle* played by each of these actors in the revolution of scientific thought. In following the author through his analysis of "De revolutionibus," we realise not only the great mental power but also the heroism of the "quiet student at the shore of the Baltic," and we feel the importance of the moment when his work is ushered into the world with Osiander's apologetic introduction. We must agree with the author's endeavour to show how little Copernicus could have been influenced by Philolaus and the vague ideas of Aristarchus, whose anticipations detract nothing from the originality of his own thoughts. On the other hand, the exposition of the defects of the system is so lucid that it requires no intimate technical knowledge of astronomy to recognise the necessity of modification, which so immediately urged Tycho to the invention of his ingenious compromise between the geocentric and heliocentric conception.

How far Tycho's all-important work as an observer has paved the way for the final recognition of the true system by Kepler is admirably shown in the last chapter, where the author opens before us the successive paths along which, through a labyrinth of errors and failures, the never tiring genius of Kepler was finally led to the "golden portal of truth." The long and weary road he had to go before he finally broke away from the time-sacred idea of circular motion and the Ptolemaic *punctum aequans,* and proved conclusively the elliptic character of the Martian orbit, is brought before us by an exhaustive analysis of his works, the study of which is so highly instructive, not only from the scientific, but also from the psychological point of view. The reproach, often levelled against the author of the "Mysterium Cosmographicum," of having filled his books with all sorts of mystic fancies, is, in Dr. Dreyer's opinion, founded on a misconception of Kepler's object in making his investigations. "There is the most intimate connection between his speculations and his great achievements; without the former we should never have had the latter."

We cannot attempt to enter upon the author's review of the opinions of science and church on the Copernican system during the time between Kepler and Newton, with which, on the whole, the student of history is familiar, though it is particularly interesting to hear on this matter the verdict of an historian who has derived his knowledge so directly and completely from an exhaustive study of the original prints and manuscripts.

It is difficult to emphasise sufficiently the specific merits of a work of this kind in a brief review. Doubtless not the least of its many meritorious features is the lucidity and conciseness of exposition. In its endeavour to grasp the essence of the cosmogonic ideas the mind is nowhere impeded by an unnecessary accumulation of cumbersome detail. At the same time the non-mathematical reader is supplied with sufficient technical information to secure his acquaintance with the principal geometry of the cosmic systems under discussion. This latter advantage is important in the case of a work which is clearly not written for a limited circulation among the small section of astronomical experts, but may justly claim to appeal to all who are interested in the history of the general development of scientific culture.

PROF. EHLERS'S "FESTSCHRIFT."

Zeitschrift für wissenschaftliche Zoologie. Vols. lxxxii. and lxxxiii. *Festschrift zur Feier seines siebzigsten Geburtstages am* 11 *Nov.* 1905, *Herrn Geheimen Regierungsrat Prof. Ernst Ehlers.* Band i., pp. iv+692; Band ii., pp. 741; and plates. (Leipzig: Engelmann, 1905.) 2 vols., price 5*l.*

THE distinguished zoologist in whose honour these volumes are issued is widely known as an indefatigable worker and one of the most genial of men. Together with the late von Kölliker, Prof. Ehlers has for many years edited the journal which now celebrates his seventieth birthday. As a testimony of the inspiring character of his teaching and of the regard in which he is held this "Festschrift" gives abundant witness. With no less clearness it indicates the diverse activities of modern zoologists and the particular problems upon which they are engaged.

With such a varied content, the volumes are difficult to review. The systematic work, admirable as it is, and coordinating or expanding as it does our knowledge of annelids, starfish, and flat-worms, can only be mentioned; nor can we do more than indicate the purport of a few of the many anatomical and physiological papers.

The place of honour is appropriately given to von Kölliker's paper on the histogenesis of the vertebrate nervous system, the last contribution of the master of histology, whose amazing vitality at eighty-seven years enabled him to conduct research and to discuss difficulties of fact and interpretation with unabated zeal. The month in which this latest defence of the neuron-theory was published brought the tidings that von Kölliker had ceased from work.

A long and exquisitely illustrated memoir by Vejdowsky gives a minute account of the structure and mode of origin of the annelidan vascular system. The nature of this system in the lower animals has been of late the goal of much research. Under the influence of the trophocœl theory, as stated by Lang on the basis of Bergh's work upon annelids, the vascular system has come to be regarded generally as a mesodermic structure, its cavities as a schizocœl, and not, as had often been suggested, a blastocœlic structure. The results of Vejdowsky's work have led him to a very different conclusion. First he proves, what had often been denied, that annelids possess a vascular endothelium. He finds that this "vasothelium" arises in the following way. Blood-vessels are intimately associated with the gut. Their cavities are at first simply a space between the outer ends of the gut-cells and their basal membrane. Into this space cells are budded off from the endo-

© 1906 Nature Publishing Group